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ABSTRACT

Asymmetric Information Acquisition in Credit Auctions

by Michael Tröge

The intensity of credit screening in a banking duopoly is endogenized under two different assumptions. In the first case each bank observes its competitior's investment in information acquisition before making a credit offer. In the second case information acquisition and bidding in the credit market take place simultaneously. The paper shows that the first assumption leads to asymmetric situations where one bank specializes in information acquisition, whereas in the second case we have symmetric equilibria. Welfare and the firm's profit are higher in the symmetric case. This means that anonymous banking markets are more competitive than markets where banks have good information about each others.

ZUSAMMENFASSUNG

Informationserwerb in Kreditauktionen

Der Artikel untersucht die Anreize von Banken in einem Duopol Kreditwürdigkeitsprüfungen durchzuführen unter zwei unterschiedlichen Annahmen. Einmal wird angenommen, daß die Banken jeweils wissen wie gut der Wettbewerber die Kreditwürdigkeit einer Firma untersucht hat. Im zweiten Fall finden Kreditwürdigkeitsprüfungen und das Kreditangebot gleichzeitig statt, so daß keine Information ausgetauscht werden kann. In dem Aufsatz wird gezeigt, daß die erste Annahme zu asymmetrischen Situationen führt, in denen eine Bank sich auf die Firma spezialisiert und sehr genaue Kreditwürdigkeitsprüfungen durchführt, wohingegen die andere Bank keine Anreize mehr hat, sich Informationen über die Firma zu beschaffen. Bei simultaner Wahl von Kreditwürdigkeitsprüfungen und Kreditangebot ergeben sich symmetrische Gleichgewichte. Es kann gezeigt werden, daß sowohl die Wohlfahrt als auch die Firmenprofite im zweiten Fall höher sind, d.h. der Wettbewerb in anonymen Märkten ist stärker als in Märkten, in denen Banken gute Informationen über das Verhalten der Wettbewerber haben.

1 Introduction

The effort invested by banks in evaluating the creditworthiness of their clients is an important factor determining the allocation of capital in an economy. This is especially true for countries with bank dominated financial systems like Germany, but as Mayer (1988) has pointed out even in the strongly market oriented economies of Anglo-Saxon countries, banks provide the biggest part of external finance.

This paper analyzes how the incentives to invest in creditworthiness tests depend on the information banks possess about each other and shows how this in turn will affect credit market competition. The main result of the paper is that close relationships between banks, with good knowledge about each other's activities will lead to a specialization of a single bank on one firm. One bank will acquire a lot of information about the firm, whereas the competitors have no incentives to acquire very good information. Being aware of the fact that there is already a bank specialization on a given firm they know that costly information acquisition will not be worthwhile. Hence information with asymmetric quality endogenously arises.

In contrast, if the banking market is anonymous and banks have no information about their competitors' screening effort, every bank will invest the same effort in creditworthiness tests. The paper shows that this case is informational more efficient as well as more competitive than the asymmetric situation. More firms are financed and the expected interest rates for the firms are lower.

This effect could explain, why in countries like Germany or Japan, where only a few banks cooperate closely and entertain clublike relationships with each other, typically firms are assigned to one housebank. Often these close and long lasting relationships have been seen as one of the factors of these countries economic success. As this paper shows, however, specialization of banks is not necessarily beneficial.

The paper brings together two strains of the literature on banking: the discussion of the benefits of banking relationships versus the danger of a hold up and the papers trying to endogenize the screening effort of banks.

The literature on bank firm relationships has analyzed the effect of asymmetric information between banks. Most existing literature has assumed that, whereas banks are completely competitive at the outset, information spontaneously acquired during a lending relationship can lead to an ex post monopoly situation. This approach has been pioneered by Sharpe (1990). He constructs a multiperiod model of a lending relationship where banks can acquire reputation not to exploit these informational advantage at the borrower's expense and implement socially optimal investment. Fischer (1990) and Rajan's (1992) construct more elaborate models, trading off the benefits of a lending relationship versus the danger of ex post rent extraction.

This paper shows that banks are not necessarily perfectly competitive and explains why banks are able to earn rents, which will not be competed away ex ante. Taking the screening efforts into account, firms may in fact be trapped in an informational monopoly with a bank, even before a lending relationship begins.

A growing literature has tried to model the incentives of banks to acquire information before giving a loan, but focussed on symmetric equilibria. Most of these papers use the sealed bid common value auction approach to bank competition, initiated by Broecker (1989). Riordan (1993) endogenizes the acceptance level of banks, but in his paper the informativeness of the creditworthiness tests is still exogenous. Kannianen and Stenbacka (1998) try to completely endogenize the screening effort and analyze the socially inefficient distortions of the banks screening effort caused by competition. In a similar setting, Gehrig (1998) shows that if information acquisition is taken into account, monopolistic outcomes are stable with respect to competition.

In fact endogenizing the information acquisition of bidders is still an unsolved problem in general auction theory. Matthews (1985) has formulated an auction with bidders of asymmetric information and endogenised the information acquisition in the context of pure common values and closed bidding. Despite assuming a quite simplified information acquisition technology, he is not able to ensure the existence of an equilibrium. One way to get around the mathematical difficulties is to assume a discrete information acquisition technology and solve the mixed equilibrium strategies. This is how Hausch and Li (1993) proceed. Ruckes (1998) has adapted this method for modeling banking competition. He is able to show that competing banks will change their credit standards with the quality of the firms in the market. If there are a lot of good firms they will be much more lenient than if the risk of credit losses is high.

Our paper uses a common value, sealed bid setting for modelling imperfect credit market competition with asymmetric information. A duopoly is considered, in which the quality of both banks' information can be varied continuously and independently. The model includes therefore the Ruckes (1998) duopoly model, where banks have information of symmetric quality, as well as the Fischer (1990)/Rajan (1992) models, where a perfectly informed bank competes against a completely uninformed one.

The paper may also be interesting for general auction theory. Despite the simple structure of the model, information acquisition can be a strategic substitute as well as a strategic complement, depending on the ex ante quality of the sample.

The next section presents the auction model of credit market competition. We derive the equilibrium for the bidding stage in section three and endogenize then the information acquisition in the sequential and simultaneous move games in section four. In the fifth section we evaluate the impact on welfare and the firm's cost of financing and the last section concludes.

2 The model

The market consists of two banks competing to give a credit to one firm. The size of the loan is normalized to one. The firm has an investment project, which is going to succeed with probability λ. In this case the firm's return is X, whereas the unsuccessful projects return nothing and the firm goes bankrupt.

By taking a close look at the firm, for example by examining the books, analyzing the feasibility of the firm's project and evaluating the quality of the firm's staff, banks are able to get better information about whether the firm is going to be successful. However, this information will not come without cost.

This situation is modeled by assuming that banks are equipped with a costly information production technology. Investing γq^2 in information acquisition, a bank independently receives with probability q a perfect signal about the quality of the firm. This means that with probability q this bank will know with certainty if the firm is going to succeed or not, whereas with probability $1 - q$ the bank does not receive additional information. It is important to note that they do not know whether the competitors have received any information.

However, banks may or may not observe the competitor's investment in information acquisition, i.e. the quality of the competitor's information. In narrow markets with good relationships between the banks, it seems reasonable to assume that they know the probability q_j, with which the competitors receive information about a given firm. In this case, the choice of q_i has to be modeled as an independent first step of the game. Before the offers are made in the second step, q_i will be revealed and cannot be changed anymore. The investment has therefore commitment value. This is the approach taken in the first part of this paper. It will be shown that this leads to asymmetric situations which are less competitive.

Alternatively, the investment in information acquisition and the decision about the offer can be modeled as simultaneous choices in a one step game with two decision variables. This is the more appropriate way of modelling anonymous markets with a lot of banks where it cannot be assumed that every bank knows how well informed the competitors are. In the second part of this paper, it will be shown that this game leads to more competitive symmetric equilibria.

Depending on their information, the banks may offer the firm a credit, asking for the repayment of b in case of success. As the investment has been normalized to one, this corresponds to an interest rate of $b-1$. The bidding is assumed to be closed i.e. banks do not know the competitor's bids nor the fact that the competitor has made an offer.

It is clear that whenever a bank has received the information that the firm is going to fail it will not make a credit offer. Accordingly when a bank knows that the project is going to succeed it will always offer credit. In case a bank has received no additional information it may or may not offer credit, depending on the ex ante probability of success of a firm. When deciding about the interest rate, a bank faces a trade-off between a higher profit in the case of winning and a higher probability of winning but a lower interest rate. Similar to other auctions with discrete values, this game has no equilibrium in pure strategies. If one bank were always bidding the same interest rate, the best response of the other bank would be either to slightly undercut this bid or to always bid the highest possible amount. Clearly, in both cases the first bank's bid is not optimal.

3 Bidding Equilibrium

In this section, the bidding stage of the game is solved assuming that the two banks have already received information with the probabilities q_1 and $q_2 \in (0,1)$. The solution of the bidding game will be used to solve the simultaneous as well as the sequential game with information acquisition. Without restriction of generality $q_1 \leq q_2$ is imposed.

An bidding equilibrium in mixed strategies can be described by the bidding densities $F_j(b)$ of bank j in case it has received a good signal, the probability μ_j of making an offer in case the bank j has not received a signal and the distribution of the bids $H_j(b)$ in case the bank is bidding without having received a signal. The profit of a bank i, having received a good signal and bidding b, can be calculated as follows:

$$\pi_i^g(b) = (b-1)\left[q_j(1-F_j(b)) + (1-q_j)\left[1-\mu_j H_j(b)\right]\right], \quad i,j = 1,2 \tag{1}$$

This is the profit on the credit business $(b-1)$ multiplied by the probability of giving the loan. If bank i has received a good signal, the project must be successful. This means that, if the competitor j also receives a signal, this must be a good signal. He will therefore make an offer which, with probability $1 - F_j(b)$, will be higher than the offer b made by bank i. With probability $1 - q_j$, bank j will not receive a signal. In this case bank j will make an offer with probability μ_j. This offer will not be accepted with probability $1 - H_j(b)$.

The profit of bank i, offering credit at an interest rate of $b - 1$ despite not having received a signal, can be obtained with similar reasoning:

$$\pi_i^0(b) = -(1-\lambda)\, q_j + (b-1)\,\lambda q_j\,(1 - F_j(b)) + (\lambda b - 1)(1 - q_j)\left[1 - \mu_j H_j(b)\right], \quad i,j = 1,2 \tag{2}$$

In a mixed strategy equilibrium, a bank must be indifferent between bids on the support of its bidding distribution. This condition leads to a set of four equations which, for $q_1 \neq q_2$, have a unique solution. The equilibrium is, however, quite complicated. The following definitions will facilitate the presentation:

Definition 1 *The bids b_1, b_2, the disjunct intervals $\mathcal{I}_1 \ldots \mathcal{I}_5$ in the bidding space, and the probabilities μ_1^b and μ_1^c are defined as follows:*

$$\begin{aligned}
\mu_1^b &:= 1 - \frac{(1-\lambda)}{(1-q_1)(X-1)\lambda}, & \mu_1^c &:= 1 - \frac{(1-\lambda)\, q_2}{(1-q_1)(X\lambda - 1)}, \\
b_1 &:= \frac{1-\lambda q_1}{\lambda(1-q_1)}, & b_2 &:= \frac{1-\lambda q_2}{\lambda(1-q_2)}, \\
\mathcal{I}_1 &:= \left(-\infty, \frac{1}{\lambda}\right), & \mathcal{I}_2 &:= \left[\frac{1}{\lambda}, b_1\right), \\
\mathcal{I}_3 &:= [b_1, b_2), & \mathcal{I}_4 &:= [b_2, X) \ \text{if } b_2 < X, \\
\mathcal{I}_5 &:= [X, \infty).
\end{aligned} \tag{3}$$

The assumption $q_1 < q_2$ implies $b_1 < b_2$. Depending on whether $b_1 > X$, $b_1 < X < b_2$ or $X > b_2$, the equilibrium takes three qualitatively different forms.

Proposition 2 *(equilibrium strategies) If two banks are receiving information with probability q_1 and q_2, $0 < q_1 < q_2$, the equilibrium is of the following form:*

a) If $X < b_1$, both bidders only bid if they have received a good signal. Their bids are distributed according to:

$$F_1(b) = \begin{cases} \frac{1}{q_1}\left[1 - (1-q_1)\frac{X-1}{b-1}\right] & \textit{for } b \in [q_1 + X - q_1 X, X], \\ 0 & \textit{for } b < q_1 + X - q_1 X, \\ 1 & \textit{for } b > X, \end{cases} \tag{4}$$

$$F_2(b) = \begin{cases} \frac{1}{q_2}\left[1 - (1-q_1)\frac{X-1}{b-1}\right] & \textit{for } b \in [q_1 + X - q_1 X, X], \\ 0 & \textit{for } b < q_1 + X - q_1 X, \\ 1 & \textit{for } b > X. \end{cases} \tag{5}$$

b) In the case $b_1 < X < b_2$, bank 1 bids with good signal and with probability μ_1^b having received uninformative signals, whereas bank 2 only bids with a good signal. The equilibrium bidding distributions are:

$$F_1(b) = \begin{cases} 0 & \textit{for } b \in \mathcal{I}_1, \\ \frac{\lambda b - 1}{\lambda q_1 (b-1)} & \textit{for } b \in \mathcal{I}_2, \\ 1 & \textit{for } b > \mathcal{I}_3 \cup \mathcal{I}_4 \cup \mathcal{I}_5, \end{cases} \tag{6}$$

$$F_2(b) = \begin{cases} 0 & \textit{for } b \in \mathcal{I}_1, \\ \frac{\lambda b - 1}{\lambda q_2 (b-1)} & \textit{for } b \in \mathcal{I}_2 \cup \mathcal{I}_3 \backslash [X, \infty), \\ 1 & \textit{for } b \in [X, \infty), \end{cases} \tag{7}$$

$$H_1(b) = \begin{cases} 0 & \textit{for } b \in \mathcal{I}_1 \cup \mathcal{I}_2, \\ \frac{1}{\mu_1^b}\left[\frac{b}{(b-1)} - \frac{1-\lambda q_1}{(b-1)(1-q_1)\lambda}\right] & \textit{for } b \in \mathcal{I}_3, \\ 1 & \textit{for } b \in [X, \infty). \end{cases} \tag{8}$$

c) For $X > b_2$, both bidders bid with good as well as with inconclusive signals. Bank 2 will always bid, even in the case of an inconclusive signal, whereas bank 1 will only bid *with probability* μ_1^c *after having received an inconclusive signal. The equilibrium bidding distributions are:*

$$F_1(b) = \begin{cases} 0 & \text{for } b \in \mathcal{I}_1, \\ \dfrac{\lambda b - 1}{\lambda q_1 (b-1)} & \text{for } b \in \mathcal{I}_2, \\ 1 & \text{for } b > \mathcal{I}_3 \cup \mathcal{I}_4 \cup \mathcal{I}_5, \end{cases} \tag{9}$$

$$F_2(b) = \begin{cases} 0 & \text{for } b \in \mathcal{I}_1, \\ \dfrac{\lambda b - 1}{\lambda q_2 (b-1)} & \text{for } b \in \mathcal{I}_2 \cup \mathcal{I}_3, \\ 1 & \text{for } b > \mathcal{I}_4 \cup \mathcal{I}_5, \end{cases} \tag{10}$$

$$H_1(b) = \begin{cases} 0 & \text{for } b \in \mathcal{I}_1 \cup \mathcal{I}_2, \\ \dfrac{1}{\mu_1^c}\left[\dfrac{b}{(b-1)} - \dfrac{1-\lambda q_1}{(b-1)(1-q_1)\lambda}\right] & \text{for } b \in \mathcal{I}_3, \\ \dfrac{1}{\mu_1^c}\left[1 - \dfrac{(1-\lambda) q_2}{(b\lambda - 1)(1-q_1)}\right] & \text{for } b \in \mathcal{I}_4, \\ 1 & \text{for } b \in \mathcal{I}_5, \end{cases} \tag{11}$$

$$H_2(b) = \begin{cases} 0 & \text{for } b \in \mathcal{I}_1 \cup \mathcal{I}_2 \cup \mathcal{I}_3, \\ \dfrac{1}{1-q_2}\left[1 - \dfrac{b-1}{\lambda b - 1}\lambda q_2\right] & \text{for } b \in \mathcal{I}_4, \\ 1 & \text{for } b \in \mathcal{I}_5. \end{cases} \tag{12}$$

Proof. see Appendix A.1 ■

The most relevant case is a). The condition $b_1 > X$ is equivalent to $\lambda < \frac{1}{q_1 + (1-q_1)X}$, which always holds if $X\lambda < 1$, i.e. if the sample of firms is so bad that, without additional information, it is ex ante not worthwhile to finance a firm. Even if $X\lambda > 1$, for high degrees of informativeness, $b_1 > X$ still holds.

Situation b) or c) where banks bid on inconclusive signals only occur if the sample of firms is very good, i.e. $\lambda X > 1$ and the information of the banks rather low.

In the case a) the equilibrium distribution functions do not depend on λ. Figure **??** shows the distribution function of both banks in this case for $q_1 = 0.6$, $q_2 = 0.8$ and $X = 3$. Both

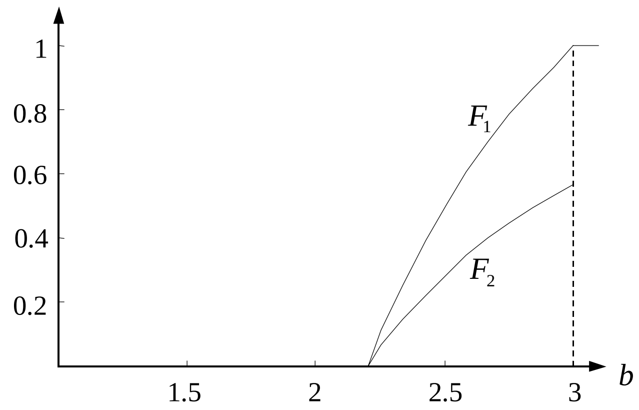

Figure 1: Case a): Bidding distributions with $q_1 = 0.6$, $q_2 = 0.8$ and $X = 3$

banks randomize on the same support. We have $F_2(X) = \frac{q_1}{q_2} < 1$. This means that the bank with the better information is bidding the highest possible bid with a positive probability. In expectation, it is also asking for a higher interest rate.

Figure ?? shows the bidding functions in the case b), for $\lambda = 0.54$, $q_1 = 0.4$, $q_2 = 0.7$, $X = 3$.

In this case, the less informed bank will bid when having received an inconclusive signal. However, it will make an expected profit of zero in these cases.

Figure 3 shows the situation c) for $q_1 = 0.4$, $q_2 = 0.6$, $\lambda = 0.6$, $X = 3$. In this case, the bank with the better information offers always a credit except if it knows that the firm is unsuccessful. It makes positive expected profit, even having received an inconclusive signal. The less informed bank only bids with probability μ_1 in case of an inconclusive signal and does not make an expected profit on these bids.

The symmetric equilibrium for two equally well informed banks with $q_1 = q_2$ has been analyzed by Ruckes (1998). However, the equilibrium described in his paper is not unique. Only in the case a) there is a unique equilibrium described by setting $q_1 = q_2 = q$ in equation 4. In case c), there is a continuum of payoff-equivalent but not welfare-equivalent equilibria:

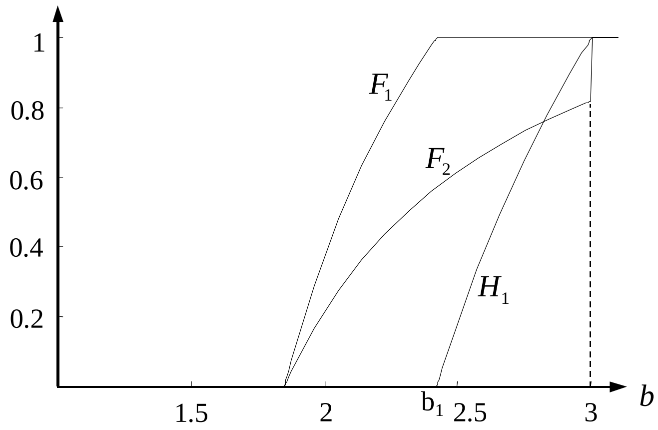

Figure 2: Case b): Bidding distributions for $\lambda = 0.54$, $q_1 = 0.4$, $q_2 = 0.7$, $X = 3$

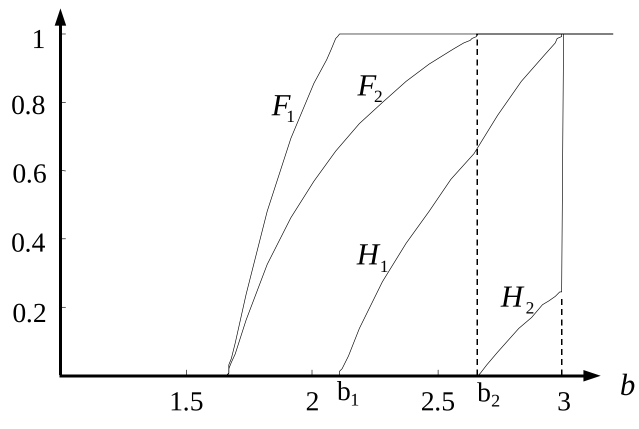

Figure 3: Case c): Bidding distributions for $q_1 = 0.4, q_2 = 0.6, \lambda = 0.6, X = 3$

Corollary 3 *(Ruckes) For*

$$\lambda > \frac{1}{q + (1-q) X} \tag{13}$$

there is a set of equilibria where, having received a good signal, both banks are bidding:.

$$F_i(b) = \begin{cases} 0 & \text{for } b \in \mathcal{I}_1, \\ \dfrac{\lambda b - 1}{\lambda q (b-1)} & \text{for } b \in \mathcal{I}_2, \\ 1 & \text{for } b > \mathcal{I}_3 \cup \mathcal{I}_4 \cup \mathcal{I}_5. \end{cases} \tag{14}$$

Having received no signal, one bank is bidding with probability $\mu_1 = 1 - \frac{(1-\lambda)q}{(1-q)(X\lambda-1)}$, *using the distribution function:*

$$H_1(b) = \begin{cases} 0 & \text{for } b \in \mathcal{I}_1 \cup \mathcal{I}_2, \\ \dfrac{1}{\mu_1}\left[1 - \dfrac{(1-\lambda) q}{(b\lambda - 1)(1-q)}\right] & \text{for } b \in \mathcal{I}_4, \\ 1 & \text{for } b \in \mathcal{I}_5. \end{cases} \tag{15}$$

The other bank has then the choice to bid with any probability $\mu_2 \in \left(1 - \frac{(1-\lambda)q}{(1-q)(X\lambda-1)}, 1\right]$ *and the corresponding distribution function:*

$$H_2(b) = \begin{cases} 0 & \text{for } b \in \mathcal{I}_1 \cup \mathcal{I}_2, \\ \dfrac{1}{\mu_2}\left[1 - \dfrac{(1-\lambda) q}{(b\lambda - 1)(1-q)}\right] & \text{for } b \in \mathcal{I}_4, \\ 1 & \text{for } b \in \mathcal{I}_5. \end{cases} \tag{16}$$

The profit of both banks is $\pi = q(1-\lambda)$.

Proof. see Appendix A.1 ■

The banks will not make profit when bidding without having received a good signal. Therefore, they are indifferent between participating at the auction or not. One of them can bid the highest value with a positive probability and participate more often in the auction without changing the indifference condition for the other bank. This will not change its profit, but increase the probability of a firm getting finance, even if both banks have received an inconclusive signal and therefore increase social welfare.

The case $p_1 = 0$, $p_2 = 1$ is especially interesting. This is the insider versus outsider situation, analyzed by Rajan and Fischer, where one bank is perfectly informed about the quality of the firm, whereas the other bank has no information. Some of the intervals $\mathcal{I}_1$... $\mathcal{I}_4$ disappear, therefore the equilibrium is not precisely included in proposition 2. However, the equations 3, 7 and 8 still describe the equilibrium.

Corollary 4 *(Fischer/Rajan) If one bank knows the quality of the firm, whereas the other is uninformed, the equilibrium strategies are:*

a) For $\lambda X < 1$, the outsider is not bidding. The insider is bidding X in case he gets a good signal and obtains the entire surplus.

b) For $\lambda X > 1$, the outsider participates with probability $\mu_1^b = \frac{\lambda X - 1}{\lambda(X-1)}$, bidding:

$$H_1(b) = \begin{cases} 0 & \text{for } b < \frac{1}{\lambda}, \\ \dfrac{(\lambda b - 1)(X-1)}{(b-1)(\lambda X - 1)} & \text{for } b \in \left[\frac{1}{\lambda}, X\right), \\ 1 & \text{for } b \in [X, \infty). \end{cases} \tag{17}$$

The insider bids

$$F_2(b) = \begin{cases} 0 & \text{for } b < \frac{1}{\lambda}, \\ \dfrac{\lambda b - 1}{\lambda(b-1)} & \text{for } b \in \left[\frac{1}{\lambda}, X\right), \\ 1 & \text{for } b \in [X, \infty). \end{cases} \tag{18}$$

Proof. See Appendix A.1 ■

The lack of information does not mean that the outsider will never win the auction, as assumed by Sharpe (1990). From 21, we see that the outsider does not make profits, but prevents the insider form earning more than an expected profit of $1 - \lambda$.

The equilibrium profits can be calculated by plugging back the equilibrium strategies 4...12 into the profit functions 1...2:

Proposition 5 ***Proof.***

Proposition 6 *In case a), the expected profit in case of having received a good signal is for both banks* $\pi_i^g = (X-1)(1-q_1)$, $i = 1, 2$. *The overall profits are therefore*

$$\pi_2 = \lambda q_2 (X-1)(1-q_1), \tag{19}$$

$$\pi_1 = \lambda q_1 (X-1)(1-q_1). \tag{20}$$

In case b), both banks make a profit of $\pi_i^g = \frac{1}{\lambda} - 1$ *having received a good signal and no profit with an inconclusive signal. Hence*

$$\pi_i = q_i (1-\lambda) \qquad i = 1, 2. \tag{21}$$

In case c), the profit after a good signal is $\pi_i^g = \frac{1}{\lambda} - 1$. *Bank two having received an inconclusive signal is making a profit of* $\pi_2^0 = (q_2 - q_1)(1-\lambda)$, *bank one is making no profit in case of an inconclusive signal. The overall profits are therefore*

$$\pi_2 = [q_2 + (1-q_2)(q_2 - q_1)](1-\lambda), \tag{22}$$

$$\pi_1 = q_1 (1-\lambda). \tag{23}$$

Proof. *see Appendix A.1* ∎

∎

4 Information Acquisition

4.1 Sequential Game

The profit of the banks depends on the quality of the own information as well as on the information of the competitors. In order to realize their profit in the second step, banks have to invest γq_i^2 in information acquisition. Using the profit formulas from proposition 6, their overall payoffs are therefore

$$\Pi_1(q_1, q_2) = \pi_1 - \gamma q_1^2, \tag{24}$$

$$\Pi_2(q_1, q_2) = \pi_2 - \gamma q_2^2. \tag{25}$$

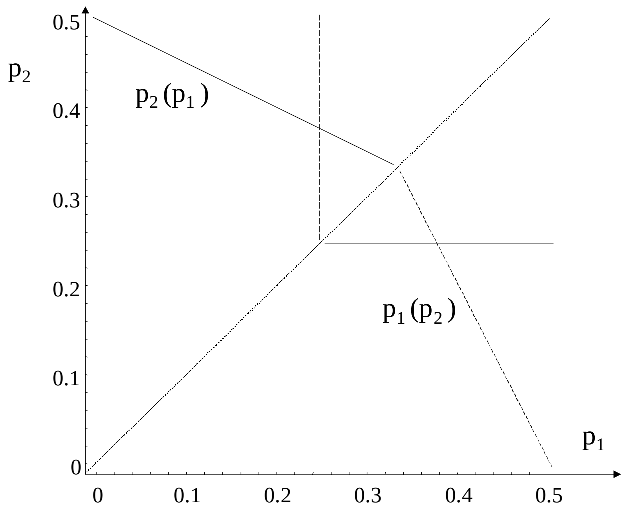

Figure 4: Reaction functions in case a): Strategic substitutes

Depending on how much information is acquired, the banks will be in situation a) or c) from proposition 2. Situation b) cannot be an equilibrium outcome. As both banks have the same profit function depending only on their own effort, the equilibrium would be symmetric which violates the asymmetry conditions for situation b).

Interestingly in the cases a) and b) the firms' reaction functions are qualitatively different. In both cases the information acquisition of the bank with the lower informational quality does not further depend on the competitors effort. However the information acquisition of the bank with the higher informational quality depends on the other's information. In case a) it decreases with the competitor's information, whereas in case c) it increases. Hence information is a strategic substitute for low quality firms and a strategic complement for high λ or X. Figures 4 and **??** show the reaction function for both cases.

Proposition 7 *a) For* $\gamma \leq \lambda \frac{2(X-1)-\lambda\left(X^2-1\right)}{\lambda X-1}$ *or* $\lambda X < 1$, *the bidders will acquire the amount of information*

$$q_1^* = \frac{(X-1)\,\lambda}{2\,(\gamma + (X-1)\,\lambda)}, \tag{26}$$

$$q_2^* = \min\left\{\frac{(X-1)\,\lambda}{2\gamma}\left[1 + \frac{(X-1)\,\lambda}{2\,(\gamma + (X-1)\,\lambda)}\right], 1\right\}. \tag{27}$$

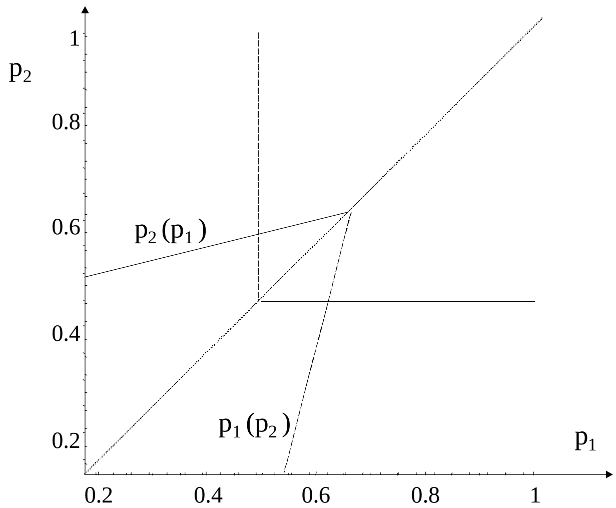

Figure 5: Reaction functions for case c): Strategic complements

b) For $\gamma > \lambda \frac{2(X-1)-\lambda(X^2-1)}{\lambda X-1}$ *and* $\lambda X > 1$,*the equilibrium levels of information will be:*

$$q_1^* = \frac{1-\lambda}{2\gamma}, \tag{28}$$

$$q_2^* = \frac{(1-\lambda+4\gamma)(1-\lambda)}{(1-\lambda+\gamma)4\gamma}. \tag{29}$$

Proof. See Appendix A.2 ■

Again a) is the most relevant case. Remarkably even if the cost of information acquisition tends to zero the outsider will not acquire more information than necessary to receive a conclusive signal in half of the cases. In particular, there will always be an outsider and an insider.

4.2 Simultaneous Choice

In this section, it will be assumed that the bidders do not observe the quality of each other's information. Therefore, information acquisition and bidding will be modeled to take place simultaneously. It is shown that a symmetric equilibrium exists in this case. A strategy for bank j in the simultaneous choice game consists of (p_j, F_j, H_j, μ_j). In equilibrium, deviating from this strategy while keeping the other players strategies fixed, should not be profitable.

However, the profit of bank j is not influenced by its choice of its own distribution functions and μ_j, as it is indifferent between any bids on the support and makes a lower profit out of the support. Once bank j has made the decision about its investment in information acquisition, its profit only depends on the competitors' actions. Therefore, in order to prove that a given strategy combination is an equilibrium, one only has to check that secretly deviating from the choice of q_j does not increase the bank's profit. If all other banks have invested q, its profit as a function of his own choice of q_i will be in case a)

$$\Pi(q_i, q) = \lambda q_i (X-1)(1-q) - \gamma q_i^2, \tag{30}$$

and in case b)

$$\Pi(q_i, q) = q_i(1-\lambda) - \gamma q_i^2. \tag{31}$$

Proposition 8 *a) For* $\gamma \leq \lambda \frac{2(X-1)-\lambda(X^2-1)}{\lambda X-1}$ *or* $\lambda X < 1$, *the bidders will acquire the amount of information*

$$q^* = \frac{\lambda(X-1)}{\lambda(X-1)+2\gamma}, \tag{32}$$

b) For $\gamma > \lambda \frac{2(X-1)-\lambda(X^2-1)}{\lambda X-1}$ *and* $\lambda X > 1$,*the equilibrium levels of information will be:*

$$q^* = \frac{1-\lambda}{2\gamma}. \tag{33}$$

Proof. Deriving with respect to q_i and imposing symmetry leads to the following conditions for an equilibrium.

$$\begin{aligned} \frac{\partial}{q_i}\Pi(q_i, q) &= \lambda(X-1)(1-q) - 2\gamma q_i = 0, && (34)\\ &\Rightarrow \lambda(X-1)(1-q) - 2\gamma q = 0, && (35)\\ q^* &= \frac{\lambda(X-1)}{\lambda(X-1)+2\gamma}. && (36)\end{aligned}$$

for case a) and

$$\begin{aligned} \frac{\partial}{q_i}\Pi(q_i, q) &= 1-\lambda-2\gamma q_i = 0 && (37)\\ q^* &= \frac{(1-\lambda)}{2\gamma}, && (38)\end{aligned}$$

for case c). ■

5 Welfare

In case a) banks are only financing if they know the project is good. Therefore, no money will be lost in financing inefficient projects. In the model, high interest rates simply redistribute the surplus, but do not cause any welfare decreasing distortions of investment decisions. Hence, welfare only depends on the probability of a project being financed:

$$W\left(q_2^*, q_1^*\right) = \lambda\left(X-1\right)\left[1-\left(1-q_1^*\right)\left(1-q_2^*\right)\right] - \gamma\left(q_1^{*2} + q_2^{*2}\right). \tag{39}$$

In case b) the project will allways be financed (recall that the bidder with the better information will always make a bid even if he has not received a signal). Under these ciscumstances, there will be welfare losses due to the bad projects which are beeing financed. However as anyway all projects will be financed informatin acquisition will be a pure social loss.

$$W\left(q_2^*, q_1^*\right) = \lambda X - 1 - \gamma\left(q_1^{*2} + q_2^{*2}\right). \tag{40}$$

The following proposition compares the welfare optimal amount of information acquisition with the equilibrium outcome. It has to be assumed that $\lambda\left(X-1\right)\frac{\sqrt{2}-1}{2} > \gamma$, in order to obtain an interior solution

Proposition 9 *In cased a) the outsider underinvests and the insider overinvests, compared to the welfare maximizing amount of information acquisition. The profits of both players are higher than in the welfare optimal equilibrium.*
In case c) both players overinvest.

Proof. Deriving equation **??** with respect to $q_1$and q_2 and solving the first order conditions yields the welfare maximizing amount of information acquisition:

$$q_1 = q_2 = q_{FB} = \frac{\lambda\left(X-1\right)}{\lambda\left(X-1\right)+2\gamma}. \tag{41}$$

Simple calculations result in:

$$q_1^* < q_{FB} < q_2^*. \tag{42}$$

Plugging the equilibrium effort q_1^* and q_2^* from 26 and 27 in the profit function 24 gives the equilibrium profits:

$$\Pi_2(q_2^*, q_1^*) = \frac{(X-1)^2 \lambda^2 (2\gamma + (X-1)\lambda)^2}{16\gamma(\gamma + (X-1)\lambda)^2}, \tag{43}$$

$$\Pi_1(q_1^*, q_2^*) = \frac{(X-1)^2 \lambda^2}{4(\gamma + (X-1)\lambda)}. \tag{44}$$

The profits for welfare maximizing information acquisition are

$$\Pi_i(q_{FB}, q_{FB}) = \frac{\gamma (X-1)^2 \lambda^2}{(2\gamma + (X-1)\lambda)^2}. \tag{45}$$

Simple algebraic manipulations prove that:

$$\Pi_2(q_2^*, q_1^*) > \Pi_1(q_1^*, q_2^*) > \Pi_i(q_{FB}, q_{FB}). \tag{46}$$

■

In the symetric situation, the first order condition **??** turns out to be identical to condition 35, defining the equilibrium intensity of information acquisition. This proves that:

Proposition 10 *In case a) the banks choose the welfare maximizing intensity of information acquisition in the equilibrium.*
In case b) both banks overinvest.

The firm's average profit can be obtained by subtracting the banks' profit, which is two times the profit of one bank, given in equation 30, from the total welfare. For case a) this is

$$CS = \lambda(X-1)[1-(1-q_2)(1-q_1)] - \lambda(X-1)[q_2(1-q_1) + q_1(1-q_1)] \tag{47}$$

$$= \lambda(X-1)[1+(1-q_1)(1+q_1)] \tag{48}$$

For case b) we obtain

$$CS(q) = \lambda X - 1 - [q_2 + (1 - q_2)(q_2 - q_1)](1 - \lambda) - q_1(1 - \lambda) \quad (49)$$

$$= \lambda X - 1 - \left[2q_2 - 2q_1 - q_2^2 + q_1 q_2\right](1 - \lambda) \quad (50)$$

6 Conclusion

The model explains why relationship banking is observed in countries with a few closely related banks. Strategic information acquisition will lead to asymmetric situations, where only one bank specializes on a firm. This bank acquires a lot of information about the firm. However, the firm will not benefit from this information acquisition. The informational advantage enables the housebank to discourage competition and ask for high interest rates. Welfare will be reduced. The only way for the firms to prevent this inefficiency is to keep the potential lenders anonymous, or at least to inhibit the exchange of verifiable information between them. In a narrow banking market, this will not be possible.

Note that the effect identified with this model is more general. In almost all common value auctions, the bidders have the possibility to inform themselves more precisely about the true value of the object. A classical example has been the selling of oil drilling rights. Similarly to the banking case, the specialization of bidders may decrease the seller's profit.

Most importantly, it has been demonstrated that good relationships between banks and good information of the banks about each other will lead to a specialization of one bank on a firm. This bank will acquire a lot of information about the firm and establish a housebank relationship. The other banks then have no incentives to increase competition by also acquiring information about the firm. This would not happen if the banks did not know the competitors' effort to acquire information. In this case the first best information acquisition effort would be invested. Hence competition in banking can be reduced quite easily. In order to partition the market no tacit collusion with punishment threads is necessary, club like relationships between banks are sufficient. Once established, tight housebank relationships can also serve as a signal that this bank is already an insider for a given firm and prevent other banks from acquiring information about this firm. The board membership of a banker may be an especially clear signal.

A Appendix

(sketchy and incomplete)

A.1 Proof of proposition 2, 6, 4 and 3

In order to verify that the distribution functions 9, 10,11 and 12 constitute an equilibrium it has to be shown that bank with a given information is indifferent on the support and makes lower profits from bidding outside the support. The general procedure will be sketched for bank 2 in case c) of proposition 2, the other cases can be treated accordingly.

i) inconclusive signal: If bank 2 has received an inconclusive signal. it is supposed to bid with the distribution 12 on the support $\mathcal{I}_4$. It has to be checked that it is indifferent between any bids on this interval. The profit of bank 2, having received an inconclusive signal and bidding on $\mathcal{I}_4$ can be calculated by plugging the functional forms of H_1,and. F_1 into equation 2:

$$\begin{aligned}\pi_i^0(b) &= -(1-\lambda)q_1+(\lambda b-1)(1-q_1)\left[1-\mu_1\frac{1}{\mu_1}\left[1-\frac{(1-\lambda)q_2}{(b\lambda-1)(1-q_1)}\right]\right] && (51)\\ &= -(1-\lambda)q_1+(\lambda b-1)(1-q_1)\left[\frac{(1-\lambda)q_2}{(b\lambda-1)(1-q_1)}\right] && (52)\\ &= (1-\lambda)(q_2-q_1). && (53)\end{aligned}$$

As required, this does not depend any more on b. In addition this is the postulated equilibrium profit, which proves proposition 6.

The above calculation holds for all b. This means that if bank 1 would bid on $\mathcal{I}_3$ with the same functional form as on $\mathcal{I}_4$, bank 2 would also be indifferent on $\mathcal{I}_3$. However for $b \in \mathcal{I}_3$ the bid distribution function H_1 is bigger than the functional form of H_1 on $\mathcal{I}_4$. Therefore the probability that bank 1 is winning is higher on $\mathcal{I}_3$, hence bank 2's profit is lower than if it was bidding on the upper interval $\mathcal{I}_4$. It is easy to see that bidding on $\mathcal{I}_1$ and $\mathcal{I}_2$ is still less profitable for bank 2.

ii) good signal: The profit of Bank 2, having received a good signal and bidding on $\mathcal{I}_3$ is

$$\pi_i^g(b) = (b-1)\left[(1-q_1)\left[1-\frac{b}{(b-1)}+\frac{1-\lambda q_1}{(b-1)(1-q_1)\lambda}\right]\right] \tag{54}$$

$$= \frac{1-\lambda}{\lambda}. \tag{55}$$

If it is choosing bids on $\mathcal{I}_2$, it is not bidding against bank 1 if bank 1 has not received a signal (because $H_1(b)=0$), but against bank 1 if it has received a good signal. The profit is

$$\pi_i^g(b) = (b-1)\left[q_1\left(1-\frac{\lambda b-1}{\lambda q_1(b-1)}\right)+(1-q_1)\right] \tag{56}$$

$$= (b-1)q_1-\frac{\lambda b-1}{\lambda}+(b-1)(1-q_1) \tag{57}$$

$$= \frac{1-\lambda}{\lambda}. \tag{58}$$

Hence bank two is indifferent on $\mathcal{I}_2 \cup \mathcal{I}_3$. For bids in $\mathcal{I}_4$, the same argument as before can be applied. The prolongation of the functional form of H_1 on $\mathcal{I}_3$ into $\mathcal{I}_4$ is smaller on $\mathcal{I}_4$ than the actual definition of H_1 on $\mathcal{I}_4$. Bank two would be indifferent for the functional form from $\mathcal{I}_3$, hence it looses with the actual definition of H_1 on $\mathcal{I}_4$. ■

A.2 Proof of proposition7

Case a) bidding only with good signals: In this case the payoff functions 24 and 25 take the form:

$$\Pi_1(q_1,q_2) = \lambda q_1(X-1)(1-q_1)-\gamma q_1^2, \tag{59}$$

$$\Pi_2(q_1,q_2) = \lambda q_2(X-1)(1-q_1)-\gamma q_2^2. \tag{60}$$

Solving this game leads to

$$q_1 = \frac{(X-1)\lambda}{\gamma + 2(X-1)\lambda},$$

$$q_2 = \frac{(X-1)\lambda}{\gamma}\left[1 + \frac{(X-1)\lambda}{\gamma + 2(X-1)\lambda}\right].$$

We have $q_2 - q_1 = \left[\frac{(X-1)\lambda}{\gamma} + 1\right]\left[1 + \frac{(X-1)\lambda}{\gamma+2(X-1)\lambda}\right] > 0$, thus the solution is consistent with the condition $q_2 > q_1$.

The condition $q_1 = \frac{(X-1)\lambda}{\gamma+2(X-1)\lambda} > \frac{\lambda X-1}{\lambda(X-1)}$ has to hold

This is true for small enough γ

$$0 < \gamma < \lambda\frac{2(X-1) - \lambda(X^2-1)}{\lambda X - 1}.$$

Case b) only bank 1 is bidding with good and bad signals In this case the equations 24 and 25 do not really constitute a game:

$$\Pi_i(q_i) = q_i(1-\lambda) - \gamma q_i^2$$

The firms' profit only depends on their own decision. But then the solution has to be symmetric which is in contradiction to being in situation b).

Case c) bidding with good and bad signals Now the banks' profit 24 and 25 can be written as:

$$\begin{aligned}
\Pi_2(q_2) &= \lambda q_2\left(\frac{1}{\lambda} - 1\right) + (1-q_2)(q_2-q_1)(1-\lambda) - \gamma q_2^2, \\
\Pi_1(q_1) &= \lambda q_1\left(\frac{1}{\lambda} - 1\right) - \gamma q_1^2.
\end{aligned}$$

For $\gamma > \frac{1}{2}(1-\lambda)$,this game has the equilibrium actions:

$$\begin{aligned}
q_1^* &= \frac{1-\lambda}{2\gamma}, \\
q_2^* &= \min\left\{\frac{(1-\lambda+4\gamma)(1-\lambda)}{(1-\lambda+\gamma)4\gamma}, 1\right\}.
\end{aligned}$$

We have $q_2^* - q_1^* = \frac{(1-\lambda)(\lambda+2\gamma-1)}{4\gamma(1-\lambda+\gamma)} > 0$. The equilibrium profits are

$$\begin{aligned}\Pi_2(q_2^*) &= \frac{\left((1-\lambda)^2 + 8\gamma^2\right)(1-\lambda)^2}{16\gamma^2(1-\lambda+\gamma)}, \\ \Pi_1(q_2^*) &= \frac{(1-\lambda)^2}{4\gamma}.\end{aligned}$$

■

A.2.1 Proof of proposition ?? and ??

Case a) bidding only with good signals Inserting the bidding distribution ?? of the $n-1$ competitors in ??, and observing that $H(b) = 0$, we obtain as the profit of a bank, having received a good signal and bidding in the interval $\left[\frac{1}{\lambda}, X\right]$:

$$\begin{aligned}\pi^g(b) &= (b-1)\left[1 - qF(b) - (1-q)\hat{\mu}_n H(b)\right]^{n-1} \\ &= (b-1)\left[(1-q)\left(\frac{X-1}{b-1}\right)^{\frac{1}{n-1}}\right]^{n-1} &(61) \\ &= (X-1)(1-q)^{n-1}. &(62)\end{aligned}$$

Hence his ex ante expected profit is:

$$\pi = \lambda q (X-1)(1-q)^{n-1}$$

Bidding lower than $\frac{1}{\lambda}$,will decrease the profit as it will not increase the probability of winning compared to bidding exactly at $\frac{1}{\lambda}$, but decrease the interest rate in the case of winning.

Case b) bidding for good and inconclusive signals: the indifference of a bank having received a good signal can be calculated as above. Plugging the equilibrium distributions ?? and ?? of the competitors into the profit function ??, shows that a bank having received an inconclusive signal is indifferent on the support and making there zero profits. It will make losses from bidding below $\hat{b}_n$.

■

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